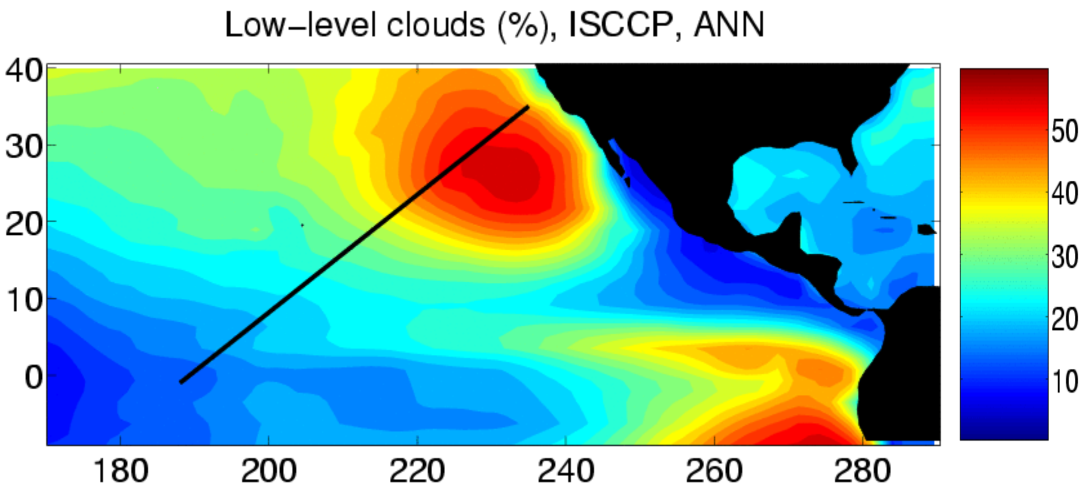
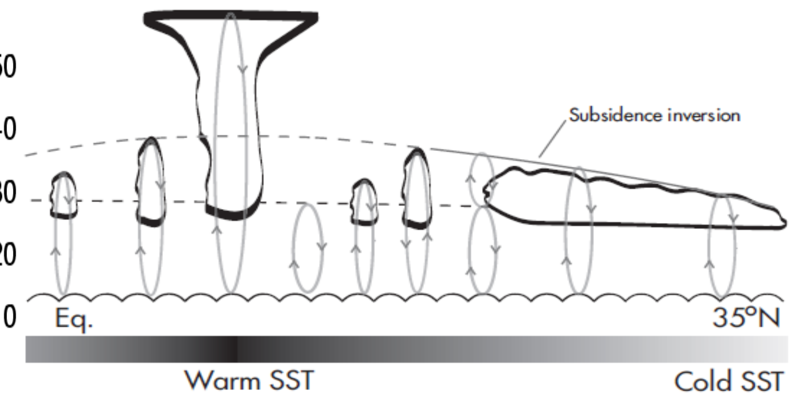
Stratocumulus to Cumulus transition CPT

Goal: Improve the representation of the cloudy boundary layer in NCEP GFS and NCAR CAM5 with a focus on the subtropical stratocumulus to cumulus (Sc-Cu) transition





Hypothesis: Sc-to-Cu transition plays key role in cloud-climate feedbacks (e.g. Teixeira et al, 2011)

NCEP H. Pan (PI), J. Han, R. Sun
NCAR S. Park (PI), C. Hannay
JPL J. Teixeira (CPT lead PI), M. Witek
U. Washington C. Bretherton (PI), J. Fletcher, P. Blossey
UCLA R. Mechoso (PI), H. Xiao
LLNL S. Klein (PI), P. Caldwell

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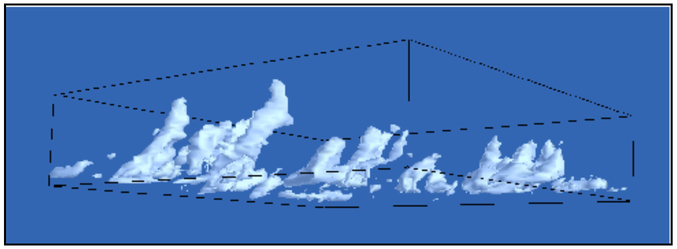
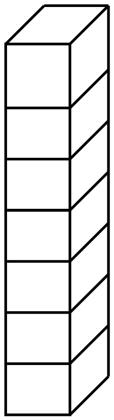
Strategy for climate model physics development

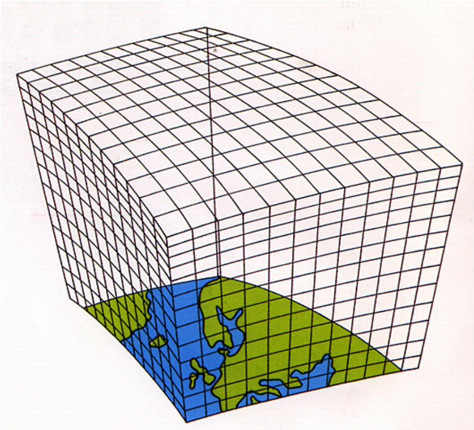


High-resolution model data:

Large Eddy Simulation (LES) models

Cloud Resolving Models (CRMs)





Testing in Single Column Models:

Versions of Climate Models

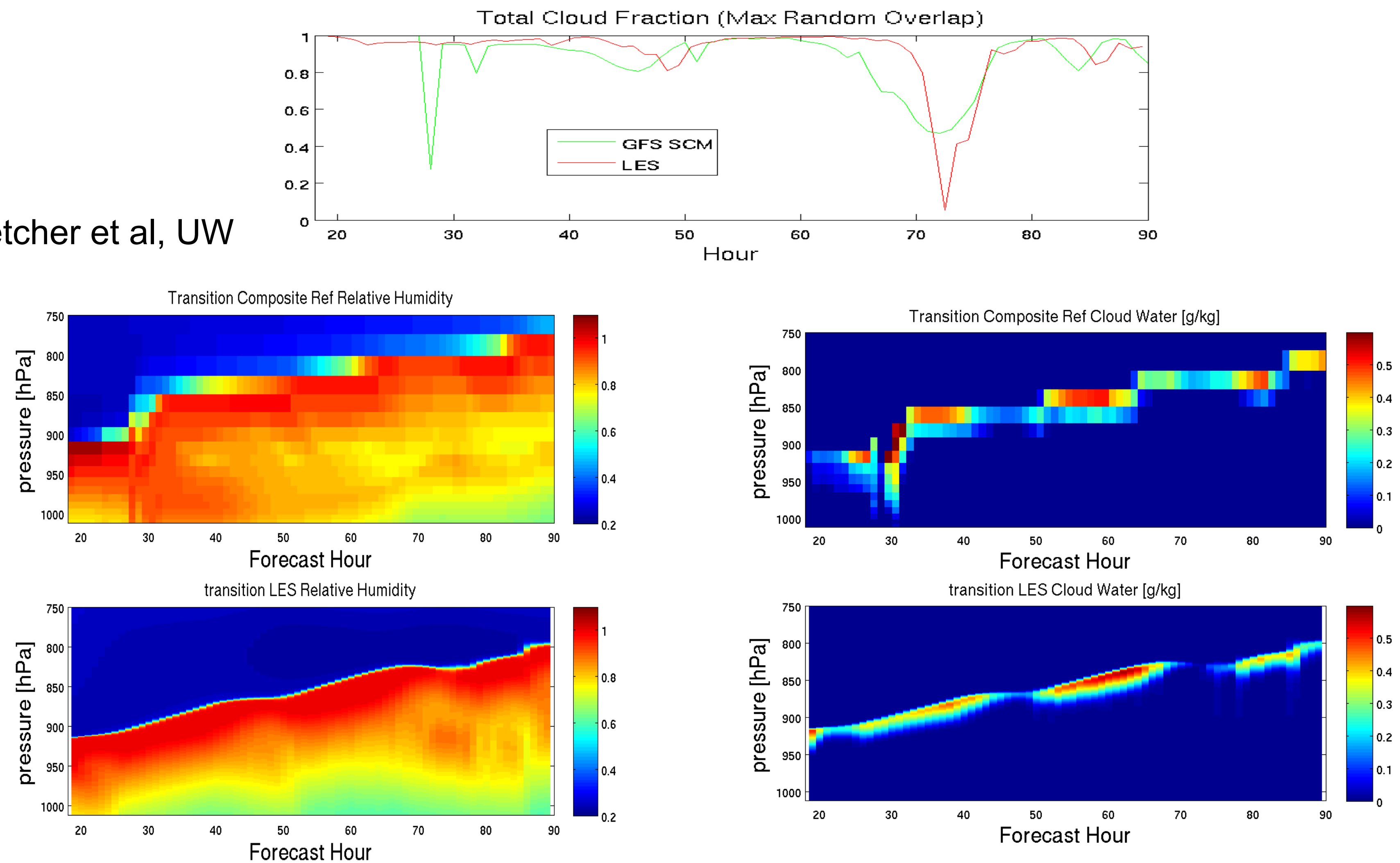
3D Climate/Weather Models:

Evaluation and Diagnostics with satellite observations

LES/CRM models provide unique information on small-scale statistics

Sc-to-Cu composite transition case with NCEP SCM

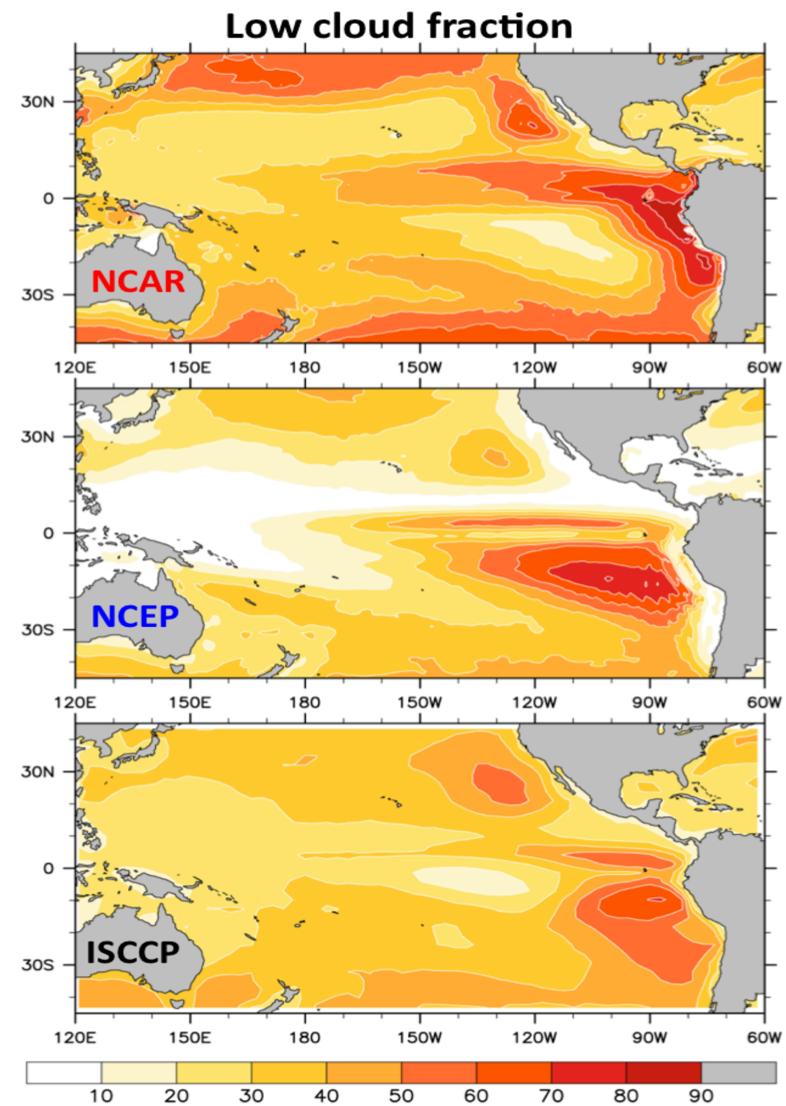
Fletcher et al, UW



NCAR and NCEP SCM results will be submitted soon
JPL LES results will be submitted soon

NCEP Model Diagnostics

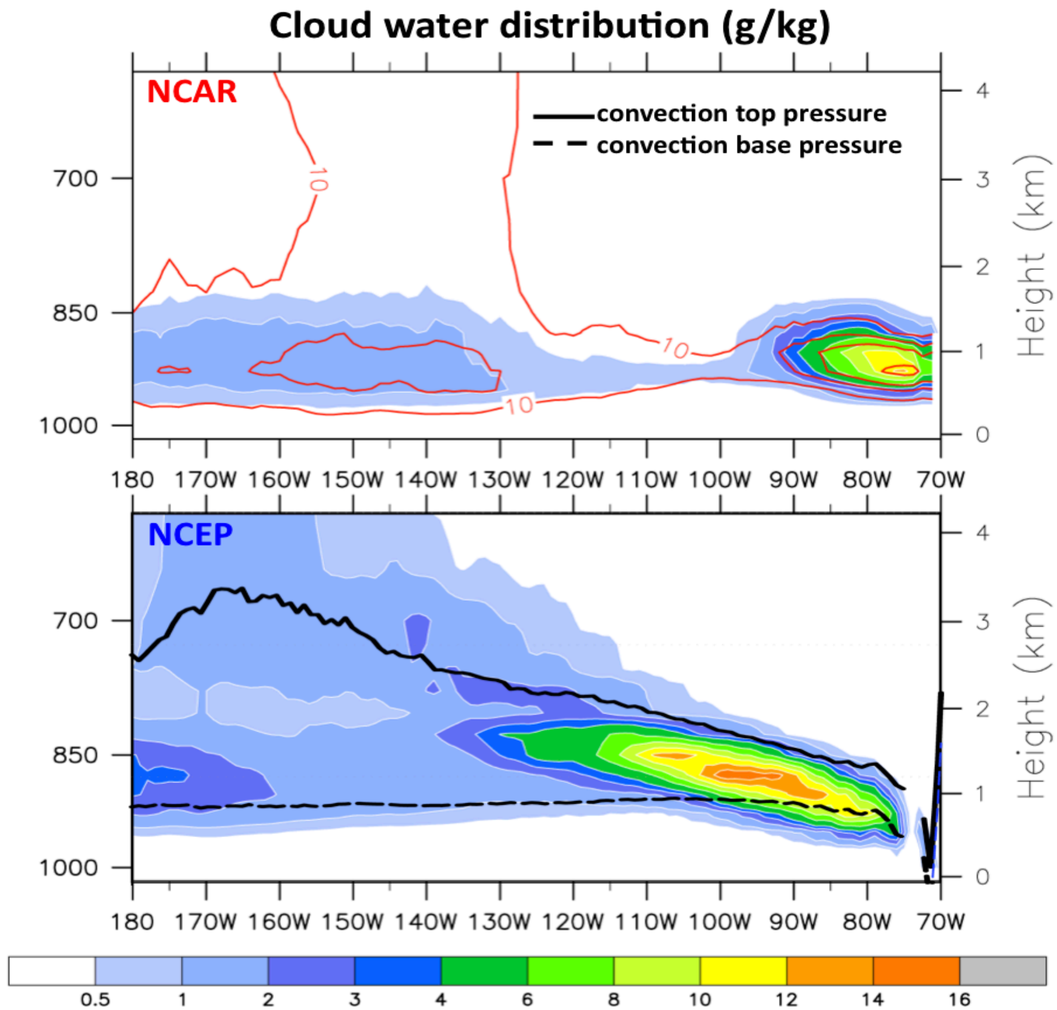
- NCAR CESM 1.0 (coupled version of CAM 5.0, 200-year run)
- NCEP CFS (coupled version of operational GFS, 20-year)
- Modified NCAR AMWG diagnostic package to add NCEP GFS output
- NCEP has TOA energy imbalance
- Both models reproduce global circulation patterns
- Both models have cloud biases



Xiao et al, UCLA

NCEP/NCAR diagnostics of cloud transition

October climatology along 20 S cross-section



NCAR and NCEP results are significantly different

Eddy-Diffusivity/Mass-Flux (EDMF)

Dividing a grid square in two regions (updraft and environment) and using Reynolds decomposition and averaging leads to

$$\overline{w'\varphi'} = a_u \overline{w'\varphi'}_u + (1-a_u)\overline{w'\varphi'}_e + a_u(1-a_u)(w_u - w_e)(\varphi_u - \varphi_e)$$

where a_u is the updraft area. Assuming a_u<<1 and w_e~0 leads to

$$\overline{w'\varphi'} = \overline{w'\varphi'}_e + a_u w_u(\varphi_u - \overline{\varphi})$$

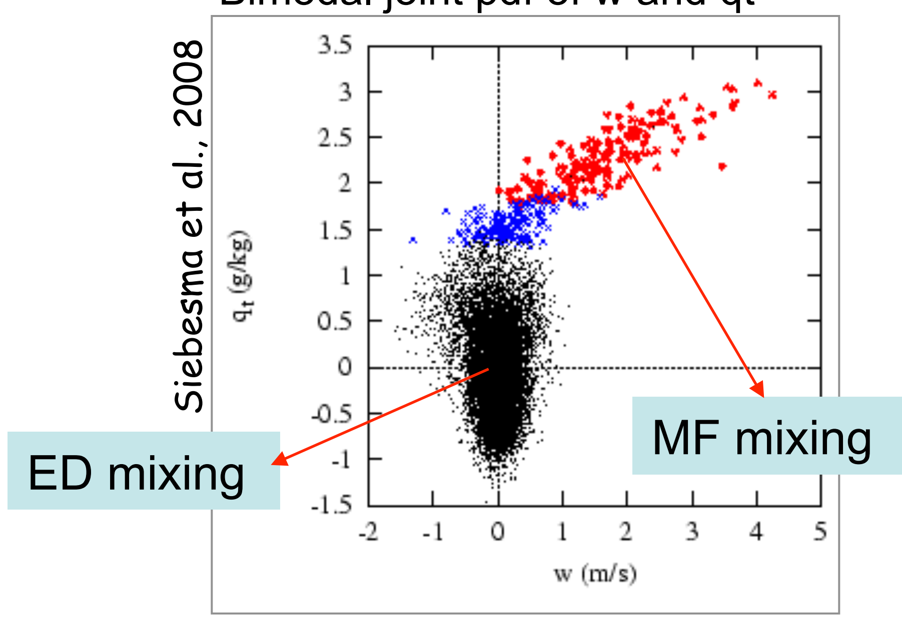
ED closure: assuming ED for 1st term and neglecting 2nd term

MF closure: neglecting 1st term and assuming $M=a_u w_u$

EDMF: $$\overline{w'\varphi'} = -k\frac{\partial\overline{\varphi}}{\partial z} + M(\varphi_u - \overline{\varphi})$$

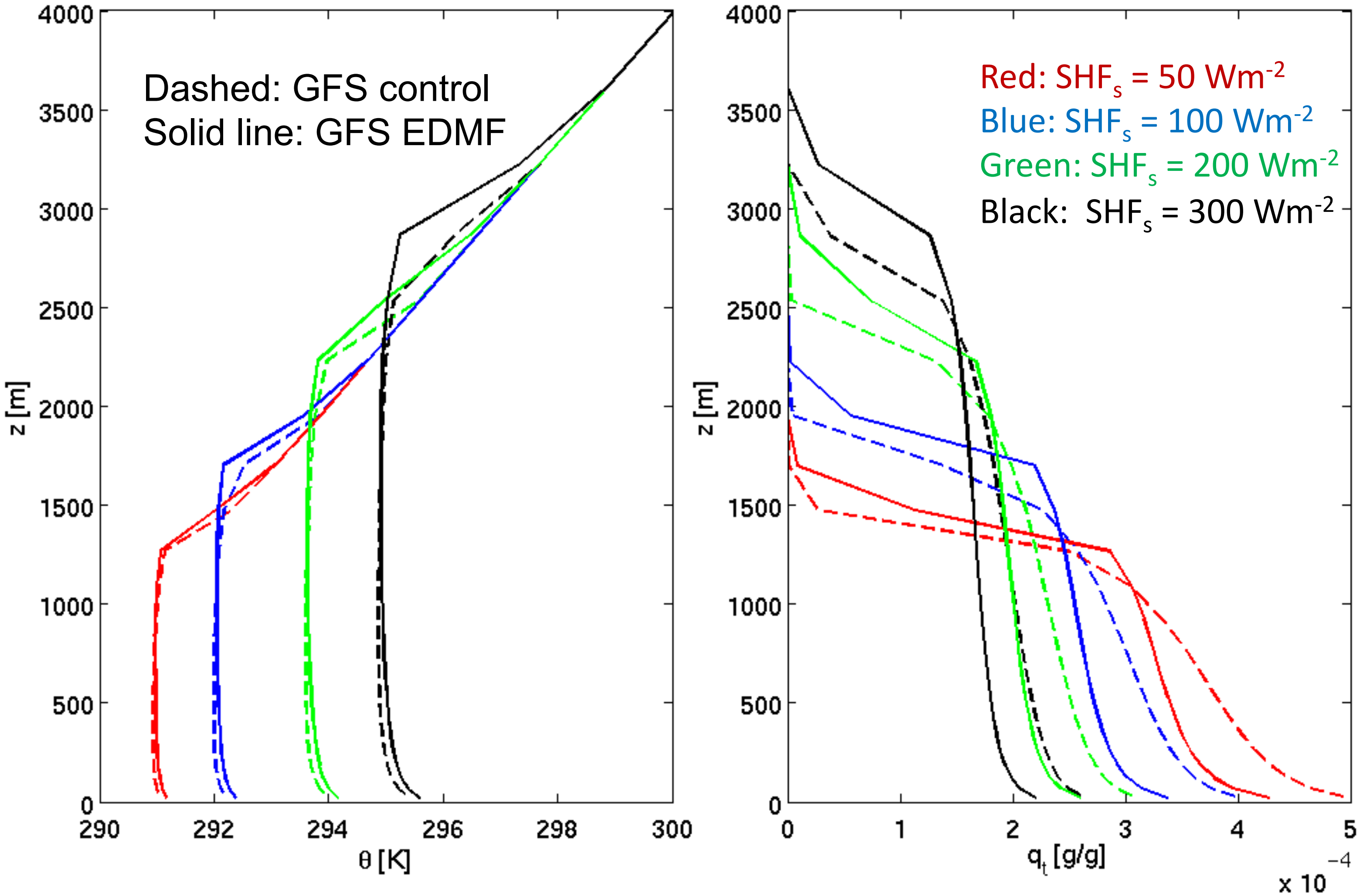
Siebesma & Teixeira, 2000

Bimodal joint pdf of w and qt



EDMF may be able to reproduce the mixing for the entire Sc-Cu transition

Implementation of EDMF in GFS SCM
Dry convective boundary layer



EDMF improves dry convective boundary layer in GFS

Sc-to-Cu Transition CPT - Summary

- GCSS Sc-Cu cases with NCAR and NCEP SCMs, and LES performed and submitted (UW, NCAR, NCEP, JPL)
- Detailed coupled diagnostics with NCEP and NCAR global models performed (NCEP, NCAR, UCLA)
- PDF cloud parameterization implemented and tested in NCAR global model (LLNL, NCAR)
- EDMF parameterization implemented and tested in SCM mode in NCEP GFS (JPL, NCEP, NCAR, UW)